are fermions with enhanced mass. In the electron system the mass enhancement for the excess electrons is even more serious. In both cases a bond pair of such fermions is always formed in the ground state. The bound pair acquires a small mass. Hence the condensed state of the composite bosons, the bound pairs, is achieved in the lower temperature phase. The mass reduction in the pair formation is described by a Gauge force. This is clearly expressed by means of the Schwinger spin bosons. The Gauge force leading to the mass reduction appears in a very local ragion. The asymptotic freedom leads to a partial justification for our mean field picture which neglects the quantum spin fluctuations. The Néel spin pattern in the background may not be a good approximation for $T>T_c$, but in the superconducting phase the spin pattern is almost stabilized through the mass reduction mechanism. The spin pattern violates the time reversal symmetry. As the CPT theorem predicts, there appears a parity violation:The bound pair is a mixture of a symmetric state and an odd parity state. The conventional GL phenomenological theory does not apply to this novel superconductivity.

## Resonating-Valence-Bond Ground State in a Large-n t-J Model

学習院大・理　田　崎　晴　明

To shed light on the roles of hole doping in strongly interacting elctron systems, we study large-n version of the t-J model. When there are holes we prove that a novel resonating-valence-bond(RVB)state, which we call the hopping-dominated RVB (hRVB) state, is the unique ground state. We conjecture the existence of a phase transition between the standard tunneling-dominated phase and the new hopping-dominated phase. By treating the hopping term in the second order perturbation, we get an exactly solvable toy model whose ground state is the nearestneighbor hRVB state.

## A Weak Coupling Expansion for the Hubbard Model on a 4×4 Cluster

Sam Houston State Univ. B. Friedman

The Hubbard model on a 4×4 cluster is studied in the weak coupling limit for half filling one and two holes. In the half filled case and for one hole the quantum numbers of the ground state agree with moderately strong coupling results. In the two hole case, to second order in U, there is more degeneracy than at intermediate coupling. The binding energy calculated via weak coupling perturbation theory captures reasonably well the binding energy at intermediate coupling. A possible extension of the weak coupling expansion to larger clusters is discussed.

## Dispersion of Low-lying Excitaions in Half-filled and Doped 1D Hubbard Model

東大・理　青木　秀夫・草部　浩　一

### 1. Introduction

Excited states as well as ground state of strongly correlated electron systems have been a subject of intense study in connection with electron mechanisms of the high Tc superconductivity. In one-dimensional(1D) systems one can provide exact results as contrasted with higher dimensional cases in which one has to make such approximations as the strong interaction limit. The exact solution for one class of excitations in 1D was first derived from the Bethe-ansatz solution by des Cloizeaux and Pearson (des Cloizeaux and Pearson 1962, see also Yamada 1969, Faddeev and Takhtajan 1986) for the Heisenberg antiferromagnet. This has been extended to the Hubbard model for the half-filled band (Ovchinikov 1970, Takahashi 1969, 1970, Woynarovich 1982) and quarter-filled band (Coll 1974). The $U=\infty$ case (Woynarovich 1982, Ogata and Shiba 1990), where $U$ is the Hubbard interaction, and the finite-size effect by conformal field theory (Woynarovich 1989) have also been studied.

In the present study we have numerically obtained the low-lying excitations for single-hole and two-hole states as well as for the half-filled band for various values of $U$ ranging $0 < U < \infty$.

Here the points of interest are the followings:

(i) How does the dispersion of low-lying excitation modes change as one goes from $U=0$ (free electron) to $U=\infty$ (Heisenberg antiferromagnet).

(ii) Although Nagaoka's theorem (Nagaoka 1966, see also Tasaki 1990)does not hold in 1D, can high-spin states emerge, and, if so, what is the dispersion like? What happens when there are more than one hole?

### 2. Method

We have obtained the wavefunctions as well as eigenenergies for the ground state and low-lying excited states for finite 1D Hubbard systems by the direct diagonalization